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G3H HAC H101 H108 H120
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(56) Documents Cited

GB 0846565 A	SU 000480908 A	US 4590796 A
US 4141240 A	US 4011757 A	US 2970473 A

(58) Field of Search
UK CL (Edition N) G1R RWF
INT CL[6] G01F 15/00 15/02
ONLINE:WPI

(54) Fluid delivery systems

(57) A device (130) for damping fluid flow from a pump (FIG 1) having a pulsed output comprises a central pipe (132) located inside tubing (134) having elastic walls and sealed at ends (136, 138). Central pipe (132) has an inlet (140) and an outlet (142) and is blocked at its centre by barrier (144) to divide the pipe (132) into two portions, an inlet portion (146) and an outlet portion (148). Holes (150, 152) are formed in both the inlet portion (146) and the outlet portion (148), and the sets of holes are not aligned with one another. This forms a tortuous path, as shown by the dotted line, for the fluid passing through the device (130) to a flow sensor (196) (FIG 7) in a photographic solution supply system.The pump comprises an oscillating slug mounted on two bellows.The slug is operated by a coil and contains a double flap valve.Other forms of damper are disclosed (FIGS 2,5 and 6).

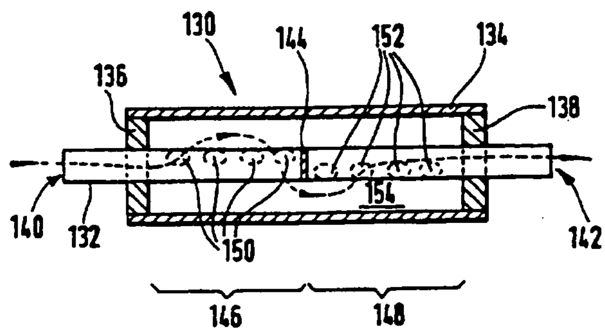

FIG.3.

GB 2 303 925 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

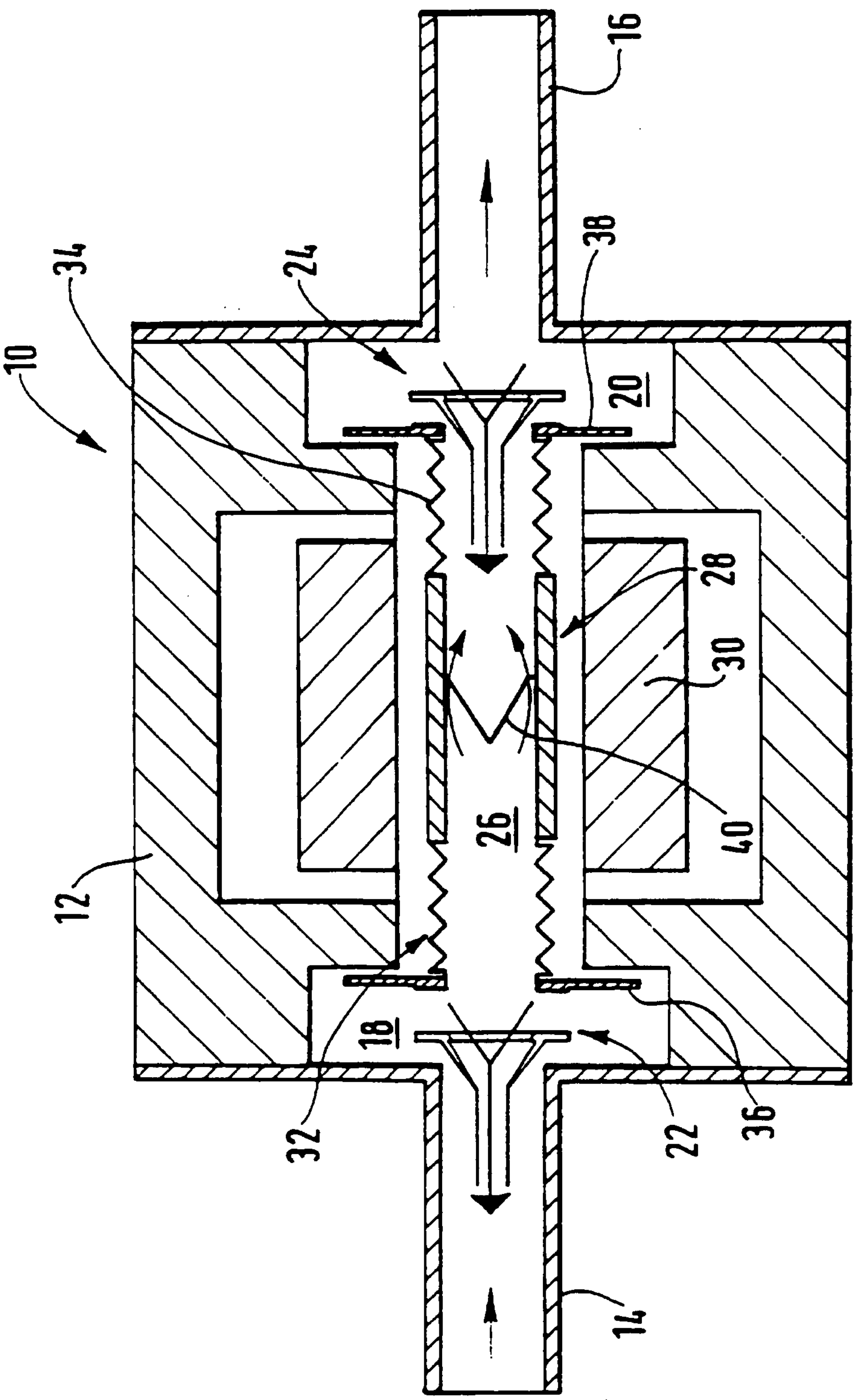

FIG.1.

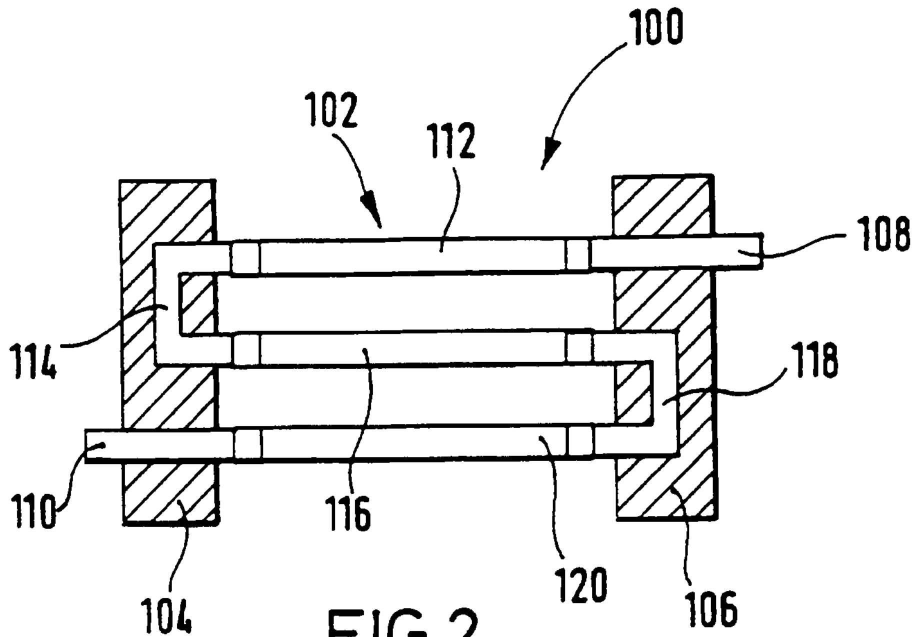
100
102
112
108
114
118
110
116
120
104
106

FIG.2.

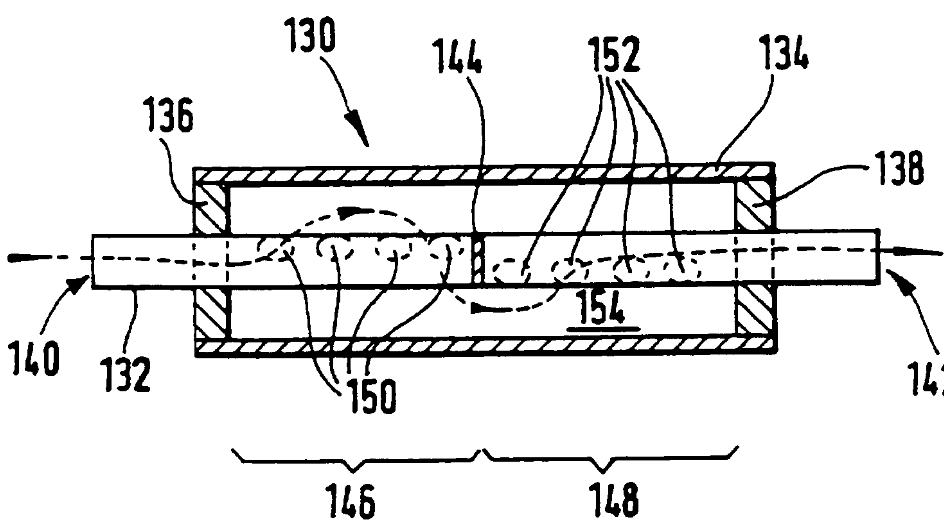
130
144
152
134
136
138
140
132
150
154
142
146
148

FIG.3.

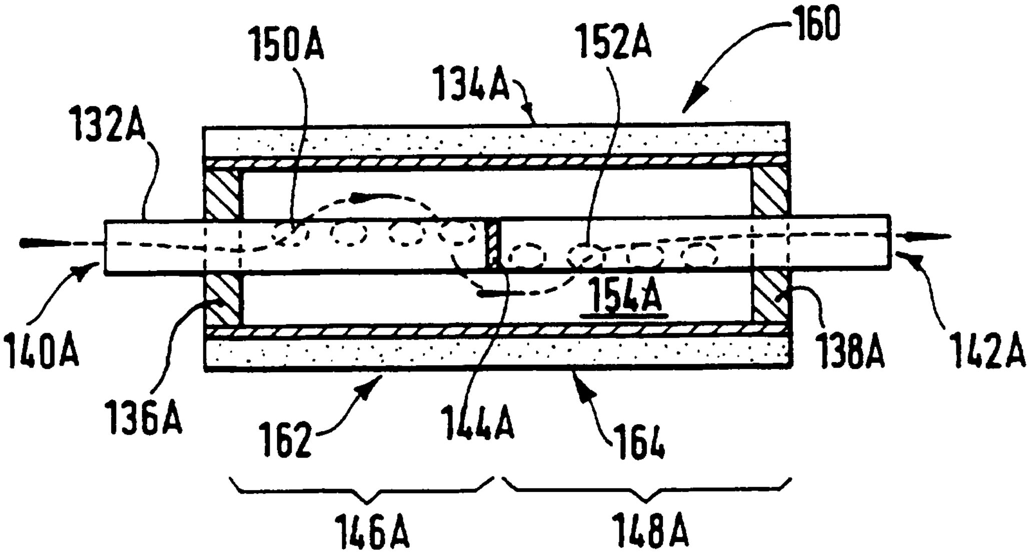
160
150A
152A
134A
132A
140A
154A
142A
136A
138A
162
144A
164
146A
148A

FIG.4.

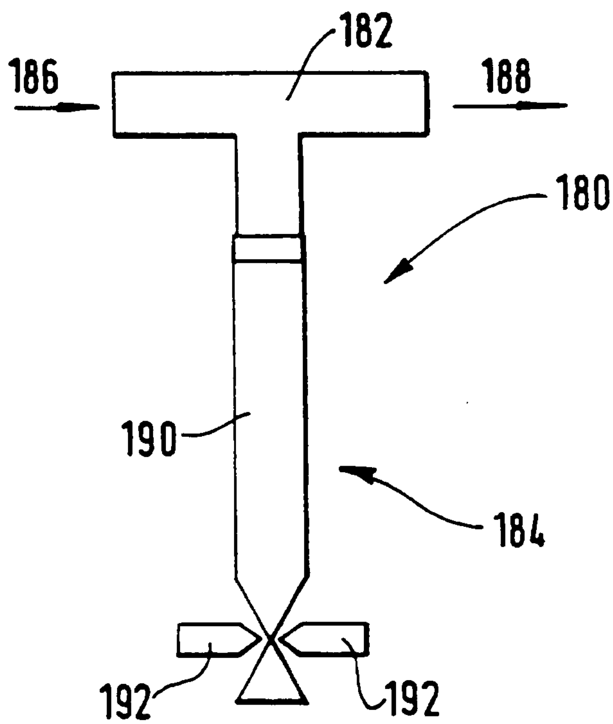
182
186
188
180
190
184
192
192

FIG.6.

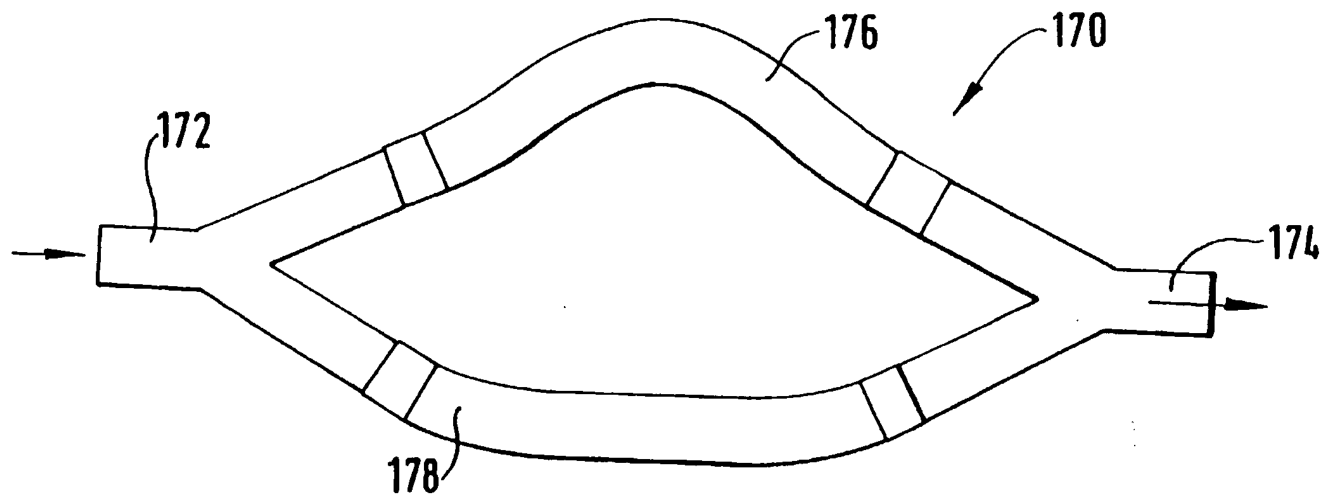

FIG.5.

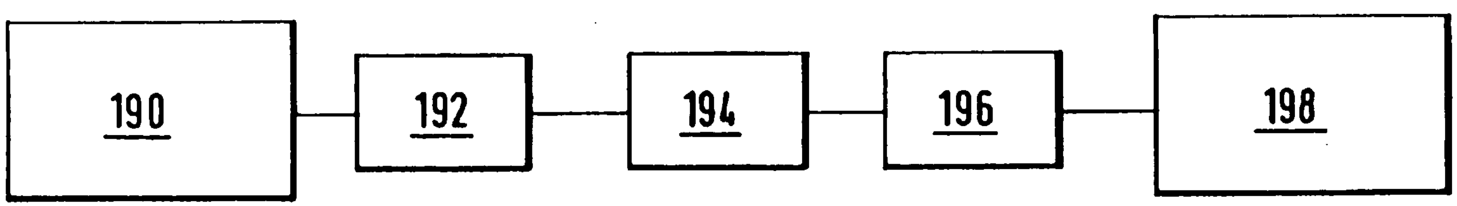

FIG.7.

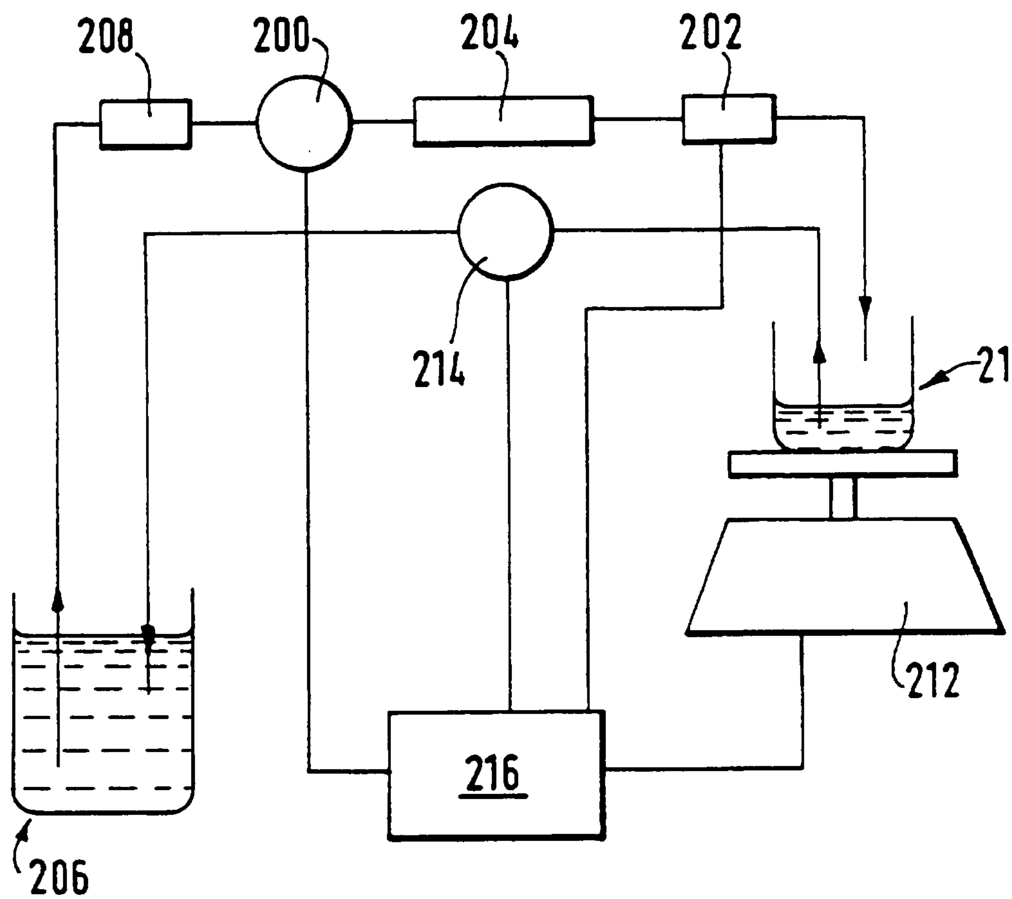

FIG.8.

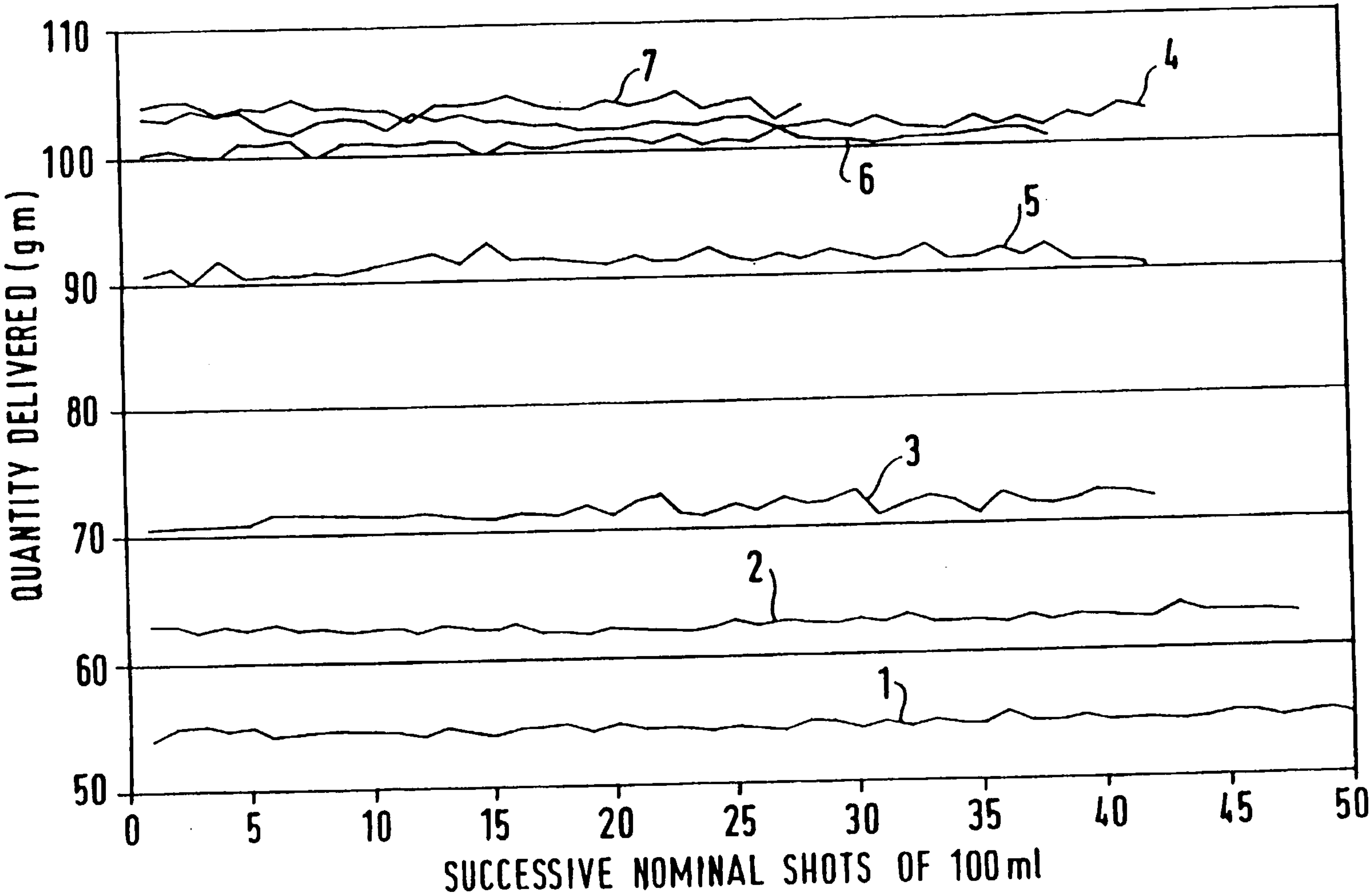
110
100
90
80
70
60
50
QUANTITY DELIVERED (gm)
0
5
10
15
20
25
30
35
40
45
50
SUCCESSIVE NOMINAL SHOTS OF 100ml
1
2
3
4
5
6
7

FIG.9.

FLUID DELIVERY SYSTEMS

Field of the Invention

The present invention relates to fluid delivery systems and is more particularly concerned with such systems where a pump having a pulsed output is used to dispense fluid to a process, a flow sensor being used to determine the amount of fluid dispensed.

Background of the Invention

In a low-cost fluid delivery system, a pump is used to deliver the required fluid from a storage container to a process container. A flow sensor is used to measure and control the quantity of fluid being delivered to the process container. The flow sensor may also be used to measure and control the rate of flow of the fluid.

The selection of the pump depends on a number of factors such as, cost, required pumping rate, resistance to chemicals, accuracy required etc. Oscillating pumps are particularly useful in such fluid delivery systems.

For an oscillating pump operating at 240V a.c., it was found that it was possible to obtain greatly improved flow rates by running the pump from half-wave rectified a.c.

A flow sensor of the turbine type may be used, the rotation of the turbine being optically or magnetically sensed to produce a series of rectangular pulses at its output. However, if the flow sensor is mounted close to the output of the oscillating pump, the output therefrom, under these conditions, tends to be inaccurate, unreliable and extremely irregular when viewed on an oscilloscope.

It is well known to dampen fluid flow to reduce the effects of pulses in a fluid system. US-A-4 248 269 and US-A-5 018 554 both disclose

methods and apparatus for damping the effects of pulses in fluid systems.

US-A-4 248 269 discloses a pulse dampener device in which the effective cross-section of the flow path therethrough is variable to allow tuning of the device so that it is possible to deal with a variety of pulse variables which may be encountered in a particular fluid flow installation. The device comprises a pressure vessel having a gas charging port at its upper end and an oil charging port at its lower end. A hollow housing is attached to the lower end of the pressure vessel and allows the flow of oil therethrough. A bladder assembly is located within the pressure vessel to divide the interior thereof into two chambers, a gas chamber in fluid connection with the gas charging port and an oil chamber in fluid connection with the oil charging port.

When the pressure at the oil port is less than the internal pressure within the gas chamber, a valve member carried by the bladder assembly is seated on a valve seat provided in the housing. When the oil pressure in the oil line, to which the device is attached, is greater than the gas pressure, oil is directed upwards into the oil chamber to unseat the valve from its seat and further compresses the gas in the gas chamber. When the oil pressure drops below that of the gas chamber, the valve is replaced on its seat. An adjustable baffle arrangement is provided in the housing for altering the flow of oil through the housing, the baffle arrangement being adjusted or tuned in accordance with the requirements of a particular installation.

US-A-5 018 554 discloses another device for damping pumps with intermittent delivery. The device comprises a slender tube closed at both ends. A feed

line and a discharge line are introduced into the tube through one of the closed ends and are sealed therein. The feed line is fluidly connected to the output of a pump, the discharge line providing an output from the damper device. Inflow opening of the feed line is positioned to be higher up the tube than the outflow opening of the discharge line so that the inflow opening no longer dips into the liquid being pumped therethrough when the pump is switched off.

Problem to be solved by the Invention

The device described in US-A-4 248 269 tends to be bulky and expensive. Furthermore, it requires a movable bladder assembly for its operation. This means that a further port is required in the device, that is, in the pressure vessel, for providing the gas pressure to the bladder assembly so that the valve can be operated to effect the required damping.

Although the device described in US-A-5 018 554 does not require a bladder assembly for its operation, its operation necessitates that it is positioned substantially vertically and, as a result, cannot easily be incorporated in all fluid flow systems.

It has therefore proved difficult to smooth out fluid flow whilst maintaining flow rate and accuracy and keeping size and cost to a minimum. This is particular the case where the fluid flow to be smoothed out has a high frequency, for example, 50Hz.

Moreover, most known damping systems require the damper device to have a particular orientation with respect to the overall system (as is the case with the device described in US-A-5 018 554).

Furthermore, in fluid delivery systems for dispensing photographic processing solutions to a photographic process or processor, it is important

that the delivery system does not include air. The presence of air reduces the effectiveness of the processing solution due to oxidation thereof.

Summary of the Invention

It is therefore an object of the present invention to provide a fluid delivery system which utilises a pump having a pulsed output to overcome the problems mentioned above.

In accordance with one aspect of the present invention, there is provided a fluid delivery system including an oscillating pump for dispensing fluid using a pulsed output, a flow sensor for measuring the amount of fluid dispensed by the pump and providing an output signal indicative of that amount, and a damper device having an inlet and an outlet by which it is connected to the system between the pump and the flow sensor, characterized in that the damper device includes absorbing means for absorbing the effect of the pulsed output from the pump enabling the flow sensor to provide an accurate output signal.

The absorbing means provides a tortuous path for the fluid between the inlet and outlet of the damper device.

Advantageously, the absorbing means comprises an outer fluid impermeable membrane and an inner tube member located within the outer membrane and defining a chamber therebetween, the inner tube element having a first portion connected to the inlet and a second portion connected to the outlet, the first portion having at least one aperture formed therein which provides fluid communication with the chamber and the second portion having at least one aperture formed therein which provides fluid communication with the chamber, the first and second portions being separated from one another within the

chamber, the tortuous path being provided by flow of the fluid from the first portion to the second portion through the chamber.

Advantageous Effect of the Invention

In accordance with the present invention, fluid flow in a delivery system can be damped using devices in which there are no moving parts. Moreover, the devices are low cost and can be mounted at any angle within the delivery system. Furthermore, pulsed outputs of any frequency can be damped using the present invention.

Moreover, when the delivery system is used for the delivery of photographic processing solutions, no air is present to oxidise the solutions.

Brief Description of the Drawings

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawings in which:-

Figure 1 is a schematic sectioned view of a typical oscillating pump with which the present invention can be used;

Figure 2 is a schematic sectioned view of one embodiment of a damper device in accordance with the present invention;

Figure 3 is a schematic sectioned view of a second embodiment of a damper device in accordance with the present invention;

Figure 4 illustrates a further embodiment of the damper device shown in Figure 3;

Figure 5 is a schematic diagram of a third embodiment of a damper device in accordance with the present invention;

Figure 6 is a schematic diagram of a fourth embodiment of a damper device in accordance with the present invention;

Figure 7 is a schematic block diagram of a fluid delivery system in accordance with the present invention;

Figure 8 is a schematic illustration of an experimental arrangement used to evaluate damper devices in accordance with the present invention; and

Figure 9 is a graph illustrating the results obtained using the arrangement shown in Figure 8.

Detailed Description of the Invention

The present invention relates to a low-cost delivery system for supplying photographic processing chemicals from a reservoir to a processing container. However, it will be readily appreciated that the present invention is not limited to such an application and can be utilised in any fluid flow system in which the pump produces a pulsed output and it is desired to measure and control the amount of fluid handled by the system using a sensitive flow sensor.

In accordance with the present invention, a device for smoothing out fluid flow between an oscillating pump and a sensitive flow sensor, in a delivery system for accurately delivering photographic processing solutions to a photographic process, was developed which meets the criteria of being able to maintain flow rate and accuracy and of keeping size and cost to a minimum.

It was found that the output from a flow sensor of the turbine type connected to an oscillating pump was inaccurate - often over-estimating the amount of fluid passing through it. This is because the flow sensor could not respond to rapid changes in flow rate caused by the pulses from the pump. With the flow occurring in 50Hz bursts, the flow sensor vane continues to rotate through the low flow phases of the

bursts, and the sensor effectively acts as a peak flow detector.

It was determined by experiment that if a flow sensor was coupled to an oscillating pump via a length of flexible-walled tubing, for example, silicon rubber tubing was used, then as the length of the tubing was increased so the output from the flow sensor became more regular and the quantity of fluid measured became more accurate. The added flexible tubing acted as a low-pass filter for the fluid flow, thereby reducing the differential between the maximum and minimum flow rates during a burst.

Another mechanism which would cause an over-estimate of the quantity of fluid flowing through the flow sensor is where the valves within the pump are not perfect.

A schematic diagram of an oscillating pump 10 is shown in Figure 1. The pump 10 comprises a body portion 12 to which an inlet nozzle 14 and an outlet nozzle 16 are connected, the inlet and outlet nozzles 14, 16 being connected respectively to an inlet chamber 18 and an outlet chamber 20. Inlet and outlet chambers 18, 20 are formed in body portion 12 as shown. An inlet valve 22 is provided in the inlet chamber 18 and an outlet valve 24 in the outlet chamber 20 as shown. A central chamber 26 is provided which connects the inlet chamber 18 to the outlet chamber 20 via respective ones of the inlet and outlet valves 22, 24.

A central oscillating slug 28 is located in the central chamber 26 and is operated by a coil 30. One end of the slug 28 is connected to bellows portion 32 adjacent inlet chamber 18, the other end being connected to bellows portion 34 adjacent outlet chamber 20. Bellows portion 32 is also attached to a

valve seat 36 against which inlet valve 22 seats. Similarly, the other end of bellows portion 34 is attached to valve seat 38 against which outlet valve 24 seats. The oscillating slug 28 also includes a double flap valve 40 which allows fluid to pass from the inlet side of the pump to the outlet side thereof, the slug 28 and valve 40 defining the division between the inlet side and the outlet side.

On a forward stroke of the pump, fluid is compressed and forced through outlet valve 24, into outlet chamber 20 and into outlet nozzle 16. At the same time, fluid is drawn into central chamber 26 through inlet nozzle 14, inlet chamber 18 and inlet valve 22. On the reverse stroke of the pump, the inlet and outlet valves 22, 24 become sealed as they seat against respective ones of the inlet and outlet valve seats 36, 38. Fluid is transferred from the central chamber 26 to the outlet chamber 20.

If the outlet valve seals slowly, or does not fully seal, there may be a very small back flow of fluid. A flow sensor positioned downstream (not shown) cannot detect a reverse flow and so the backward flowing fluid will not be accounted for. This results in the sensor over-estimating the quantity of fluid passing therethrough resulting in an under-delivery of fluid.

Figure 2 illustrates a first embodiment of a damper device for use in a fluid delivery system in accordance with the present invention. The device 100 comprises a flexible tube 102 which is supported by members 104, 106 so as to provide a triple-tube arrangement as shown. The tube 102 has an inlet 108 and an outlet 110. In this embodiment, the fluid is forced to travel a convoluted path through several short lengths of flexible-walled tubing. In

particular, fluid flows into inlet 108, through a first straight portion 112, a first bend portion 114, a second straight portion 116, a second bend portion 118 and a third straight portion 120 to outlet 110. The change in direction of flow at bend portions 114, 118 acts as a constriction improving the filtering effect.

A muffler arrangement 130 is shown in Figure 3. Here, a central pipe 132 is located inside a length of tubing 134 which has elastic walls and is sealed at ends 136, 138. Central pipe 132 has an inlet 140 and an outlet 142 and is blocked at its centre by barrier 144 to divide the pipe 132 into two portions, an inlet portion 146 and an outlet portion 148. Holes 150 are formed along the length of the inlet portion 146 and holes 152 are formed along the length of the outlet portion 148. Holes 152 are not aligned with holes 150 and are arranged to be at an angle to one another, for example, 90°. This forms a tortuous path, as shown by the dotted line, for the fluid passing through the arrangement 130.

In operation, fluid enters the inlet 140 of the central pipe and is forced to exit the central pipe 132 through holes 150 in the inlet portion 146 due to the presence of barrier 144. The fluid then flows through chamber 154 formed between the central pipe 132 and the outer tubing 134, and in through holes 152 in the outlet portion 148 and onto outlet 142.

In Figure 4, a muffler arrangement 160 is shown which is similar to the arrangement 130 described above. Like components are referenced the same but with the addition of the suffix 'A'. The muffler 160 comprises a central pipe 132A which is located inside a length of tubing 134A which has

elastic walls and is sealed at ends 136A, 138A. Central pipe 132A has an inlet 140A and an outlet 142A and is blocked at its centre by barrier 144A to divide the pipe 132A into two portions, an inlet portion 146A and an outlet portion 148A. Holes 150A are formed along the length of the inlet portion 146A and holes 152A are formed along the length of the outlet portion 148A. A chamber 154A is provided between central pipe 132A and the outer tubing 134A as before. In this embodiment, the outer tubing 134A is very thin and needs to be supported. This is achieved by mounting the outer tubing 134A within an outer casing 162. A layer of a low density foam material 164 is provided between the tubing 134A and the outer casing 162. This embodiment operates in the same way as the embodiment described with reference to Figure 3.

Figure 5 illustrates another device 170 which achieves the necessary damping of fluid flow in a system with a pulsed pump output. The device 170 has an inlet 172 and an outlet 174. Two fluid paths 176, 178 are provided between the inlet 172 and the outlet 174. Path 178 is longer than path 176 so that fluid pulses reach the outlet 174 out of phase with one another thereby cancelling the fundamental frequency of fluid oscillation. It will be readily appreciated that device 170 needs to be tuned to the particular fluid flow system in which it is to be used.

Figure 6 illustrates another device 180 which needs to be tuned to the fluid flow system in which it is to operate. The device 180 is generally T-shaped as shown comprising an upper portion 182 and a lower portion 184. Upper portion 182 comprises an inlet 186 and an outlet 188. Lower portion 184 of the T-shape comprises a stub 190 of tubing which is closed

by means of nips 192. Nips 192 are movable so that the stub 190 can be tuned to the frequency of the pulses produced in the fluid flow system in which it is connected. Nips 192 alter the effective length of the stub 190 so that a standing wave pattern is set up within the stub 190 which cancels the fundamental frequency of the fluid flow system.

Figure 7 illustrates a fluid delivery system 190, 192, 194, 196 for delivering or dispensing photographic processing solution to a photographic process 198. The system comprises a reservoir 190 containing an appropriate processing solution for the process 198. Processing solution is pumped from the reservoir 190 by an oscillating pump 192 via a damper device 194 and a flow sensor 196 to the process 198.

Pump 192 can be a pump 10 as described above in relation to Figure 1. The damper device 194 can be any one of the devices described with reference to Figures 2 to 6. The flow sensor 196 is of the turbine type, the rotation of the turbine being sensed optically or magnetically.

Experiments were carried out using some of the damper devices described above to evaluate their effectiveness. A schematic block diagram of an experimental arrangement used is shown in Figure 8. An oscillating pump 200 was connected to a flow sensor 202 by means of a damper 204. The pump 200 was mounted vertically and the flow sensor 202 was mounted above it.

Solution was supplied to the pump 200 from a container 206 via a filter 208. The solution was collected in a further container 210 mounted on weighing apparatus 212. A further pump 214 was used to empty container 210 by returning the solution to container 206. A computer 216 was connected to pumps

200, 214, to the sensor 204 and weighing apparatus 212.

Under the control of the computer 216, repeated shots of a 100ml dose of solution was dispensed by the pump 200 into container 210. The weight of the beaker 210 was taken before and after each shot and recorded. After each shot, the beaker is emptied by the pump 214.

The flow sensor 204 measured volume whilst the weighing apparatus 212 checked the weight of solution dispensed. Tap water was used as the solution so that the density could be close to unity.

The damper 204 comprised the following devices:-

DAMPER	DESCRIPTION
1	60mm of rigid PVC tubing (Griflex)
2	250mm (10in) of silicon rubber tubing
3	the embodiment of Figure 2 (above)
4	the embodiment of Figure 3 (above)
5	the embodiment of Figure 6 (above)
6	2m length of silicon rubber, tightly coiled
7	2m length of silicon rubber lying straight

Each damper was connected to the arrangement and run for 20min. The results obtained are shown in Figure 9.

It can be seen, from Figure 9, that the best results were obtained from dampers 4, 6 and 7.

The discrepancy between the nominal shot of 100ml and the actual quantity delivered is due to the calibration accuracy of the flow sensor employed.

Prior to each set of experiments, the system was purged of air and the output from the flow sensor 204 was observed using a long-persistence oscilloscope

so that some measure of the pulse jitter could be obtained. The pulse period was approximately 7ms. The results obtained are shown in Table 1.

Table 1.

DAMPER	JITTER -RISING EDGE	JITTER - FALLING EDGE
1	pulses overlap	pulses overlap
2	~2.5ms	overlap
3	~1.7ms	~2.5ms
4	~0.9ms	~1.3ms
5	~1.2ms	~2.0ms
6	~0.8ms	~1.0ms
7	~0.9ms	~1.2ms

Although the present invention has been described with reference to oscillating pumps and flow sensors of the turbine type, any suitable alternatives can be used. For example, a pump may have half-wave rectification built into it.

Other pumps in common use, for example, diaphragm pumps, also exhibit a pulsed output flow to which the present invention has application.

CLAIMS:

1. A fluid delivery system (190, 192, 194, 196, 198) including an oscillating pump (10; 192) for dispensing fluid to a process (198) using a pulsed output, a flow sensor (196) for measuring the amount of fluid dispensed by the pump (10; 192) and providing an output signal indicative of that amount, and a damper device (100; 130; 160; 180; 194) having an inlet (108; 140; 140A; 172; 186) and an outlet (110; 142; 142A; 174; 188) by which it is connected to the system (190, 192, 194, 196, 198) between the pump (10; 192) and the flow sensor (196), characterized in that the damper device (100; 130; 160; 180; 194) includes absorbing means (102; 132, 134, 144; 150, 152; 150A, 152A; 176, 178; 184) for absorbing the effect of the pulsed output from the pump (10; 192) enabling the flow sensor (196) to provide an accurate output signal.

2. A system according to claim 1, wherein the absorbing means (102; 132, 134, 144, 150, 152 154; 132A, 134A, 144A, 150A, 152A) provides a tortuous path for the fluid between the inlet (108; 140; 140A) and outlet (110; 142; 142A) of the damper device (100; 130; 160).

3. A system according to claim 2, wherein the absorbing means (132, 134, 144, 150, 152, 154; 132A, 134A, 144A, 150A, 152A, 154A) comprises an outer fluid impermeable membrane (134; 134A) and an inner tube member (132; 132A) located within the outer membrane (134; 134A) and defining a chamber (154; 154A) therebetween, the inner tube element (132; 132A) having a first portion (146; 146A) connected to the inlet (140; 140A) and a second portion (148; 148A) connected to the outlet (142; 142A), the first portion (146; 146A) having at least one aperture (150; 150A)

formed therein which provides fluid communication with the chamber (154; 154A) and the second portion (148; 148A) having at least one aperture (152; 152A) formed therein which provides fluid communication with the chamber (154; 154A), the first and second portions being separated from one another within the chamber (154; 154A), the tortuous path being provided by flow of the fluid from the first portion (146; 146A) to the second portion (148; 148A) through the chamber (154; 154A).

4. A system according to claim 3, wherein the tube member (132; 132A) is continuous, the first and second portions (146, 148; 146A, 148A) being separated from one another by a barrier member (144; 144A).

5. A system according to claim 3 or 4, wherein each aperture (150; 150A) in the first portion (146; 146A) is spaced at an angle from each aperture (152; 152A) in the second portion (148; 148A).

6. A system according to any one of claims 3 to 5, wherein the outer fluid impermeable membrane (134; 134A) comprises flexible tubing.

7. A system according to claim 6, wherein the tubing comprises rubber.

8. A system according to any one of claims 3 to 7, wherein the outer fluid impermeable membrane (134A) is enclosed in a casing (162, 164).

9. A system according to claim 8, wherein the casing (162) includes a packing layer (164) comprising a low density foam material.

10. A system according to any one of the preceding claims, for dispensing photographic processing solution to a photographic process.

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Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9515821.8
Relevant Technical Fields (i) UK Cl (Ed.N) G1R (RWF) (ii) Int Cl (Ed.6) G01F 15/00, 15/02	Search Examiner A BURROWS Date of completion of Search 9 OCTOBER 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-10

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X,Y	GB 0846565	(ENGEL) Figure 1: lines 36-39 page 2	X:1, 2 Y:10
X,Y	US 4590796	(FLOSCAN) Figure 2	X:1 Y:10
X,Y	US 4141240	(NISSAN) whole document	X:1 Y:10
X,Y	US 4011757	(FLOSCAN) column 5 lines 9-57	X:1 Y:10
X,Y	US 2970473	(KENDIG) whole document	X:1 Y:10
X,Y	SU 000480908	(VERKHORUBOV) Figure 1: columns 1 and 2	X:1 Y:10

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).